PATENT SPECIFICATION (11) 1 557 817

(21) Application No. 35451/76 (22) Filed 26 Aug. 1976
(23) Complete Specification Filed 25 Aug. 1977
(44) Complete Specification Published 12 Dec. 1979
(51) INT. CL.^{2} F02C 3/10 7/18
F02K 3/04
(52) Index at Acceptance
F1G 5C4
F1J 2A1A 2A1D

(72) Inventor: JEAN MICHAEL CLARKE

1 557 817

(19) THE PATENT OFFICE LONDON

(54) GAS TURBINE DUCTED FAN ENGINES HAVING EXPANSION TO SUB-ATMOSPHERIC PRESSURE

(71) We, NOEL PENNY TURBINES LIMITED, a British Company, of Siskin Drive, Toll Bar End, Coventry, West Midlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and method by which it is to be performed, to be particularly described in and by the following statement:-

The invention is concerned with a gas turbine ducted fan engine having expansion to sub-atmospheric pressure.

According to the invention, a gas turbine ducted fan engine comprises a compressor, a compressor-driving turbine coupled thereto, at least one power turbine downstream of said compressor-driving turbine and rotatable independently thereof, in which power turbine or power turbines gas passing therethrough is expanded to a sub-atmospheric pressure, an aftercooler by which exhaust gas from the power turbine or power turbines is cooled, after having been expanded to said sub-atmospheric pressure, a further compressor, drivingly coupled to the or at least one of the power turbines to recompress the exhaust gas to substantially atmospheric pressure, after the exhaust gas has been cooled by said aftercooler, and then to discharge said exhaust gas to atmosphere, and a fan drivingly connected to the or at least one of the power turbines and operable to draw an air stream through a duct and to discharge it as a propulsive jet.

The fan may also be arranged to draw at least part of the air stream through the aftercooler to cool the exhaust gas passing therethrough.

Said further compressor may also be arranged to discharge the exhaust gas that has been compressed therein through said duct.

Where more than one power turbines are provided, the downstream power turbine or turbines may conveniently be mounted on the same shaft as the first i.e., the upstream, power turbine and said further compressor.

By way of example a gas turbine engine in accordance with the preferred arrangement, as aforesaid, is now described with reference to the accompanying drawings, in which:-

Figure 1 is an axial section through the engine;

Figure 2 is an end view in the direction of arrow II in Figure 1, and

Figure 3 is an end view in the direction of arrow III in Figure 1.

The engine comprises an axial flow compressor having two stages. The low pressure compresssor rotor 1 is coupled through a shaft 2 to a low pressure turbine rotor 3 and the high pressure compressor rotor 4 is coupled through a tubular shaft 5 co-axially surrounding the shaft 2 to a high pressure turbine rotor 6. A combustion chamber positioned between the compressor stages and the turbines is indicated at 7. The compressor rotors 1, 4, the turbine rotors 3, 6 and their stators together with the combustion chamber 7 therefore form a two-spool gas turbine engine.

The exhaust from the low pressure turbine rotor 3 is then passed through a power turbine independently rotatable with respect to the turbine rotors 3 and 6 and having a rotor 8 connected by a shaft 9 to a fan rotor 10 arranged to draw a propulsive stream of air through a duct 11.

The exhaust from the power turbine rotor 8 is then expanded through a further power turbine independent of the turbine rotors 3 and 6 and having a rotor 12 in series with the rotor 8 and which is also mounted on the shaft 9. The turbine 12 has an expansion ratio such that the exhaust gas is expanded therein to a sub-atmospheric pressure. The exhaust gas at sub-atmospheric pressure is then cooled in an aftercooler 13 where the volume of the exhaust gas is also reduced. The cooled gas from the aftercooler 13 is

then re-compressed to substantially atmospheric pressure in a further compression stage having compressor rotor blading 14 which is formed as a radially outer extension of the fan rotor 10. After being re-compressed by the compressor rotor blading 14 to substantially atmospheric pressure, the exhaust gas is then discharged through an outer section 15 of the duct 11 to merge with the propulsive stream of air. The stream of air drawn through the duct 11 by the fan 10 is first drawn through the aftercooler 13 to cool the exhaust gas passing therethrough from the turbine 12 to the further compression stage provided by the compressor rotor blading 14. The heat imparted to the air stream in passing through the aftercooler 13 increases the volume of the air stream, thereby increasing the thrust of the propulsive air stream through the duct 11. Surplus power produced by the turbine 12 available after discharging the exhaust gas through the aftercooler 13 is used to supplement the power provided by the power turbine 8 to drive the fan 10 through the shaft 9. The overall effect of this is to reduce the specific fuel consumption since the engine provides an increase in overall pressure ratio as compared with an orthodox turbo-fan engine.

Although the gas generating section of the engine described herein is a two-spool arrangement, a single compressor and compressor-driving turbine coupled thereto may be used to provide gas to be passed through the power turbines 8 and 12.

The power turbines 8 and 12 may be mounted independently of each other or the turbine 12 may be incorporated in the turbine 8.

WHAT WE CLAIM IS:-

1. A gas turbine ducted fan engine comprising a compressor, a compressor-driving turbine coupled thereto, at least one power turbine downstream of said compressor-driving turbine and rotatably independently thereof, in which power turbine or power turbines, gas passing therethrough is expanded to a sub-atmospheric pressure, an aftercooler by which exhaust gas from the power turbine or power turbines is cooled, after having been expanded to said sub-atmospheric pressure, a further compressor, drivingly coupled to the or at least one of the power turbines to recompress the exhaust gas to substantially atmospheric pressure, after the exhaust gas has been cooled by said aftercooler, and then to discharge said exhaust gas to atmosphere, and a fan drivingly connected to the or at least one of the power turbines and operable to draw an air stream through a duct and to discharge it as a propulsive jet.

2. A gas turbine engine as claimed in Claim 1 in which the fan is also arranged to draw at least part of the air stream through the aftercooler to cool the exhaust gas passing therethrough.

3. A gas turbine engine as claimed in Claim 1 or 2 in which said further compressor is arranged to discharge the exhaust gas that has been compressed therein through said duct.

4. A gas turbine engine as claimed in any preceding claim in which there are at least two power turbines, the power turbines all being mounted on the same shaft as said further compressor.

5. A gas turbine engine as claimed in any preceding claim in which an output power shaft is provided on which the power turbine is, or all the power turbines are, where there are more than one, drivingly mounted.

6. A ducted fan gas turbine engine constructed and arranged substantially as described and shown in the accompanying drawings.

WALFORD & HARDMAN BROWN,
Chartered Patent Agents,
Trinity House,
Hales Street,
Coventry,
West Midlands.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1979. Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

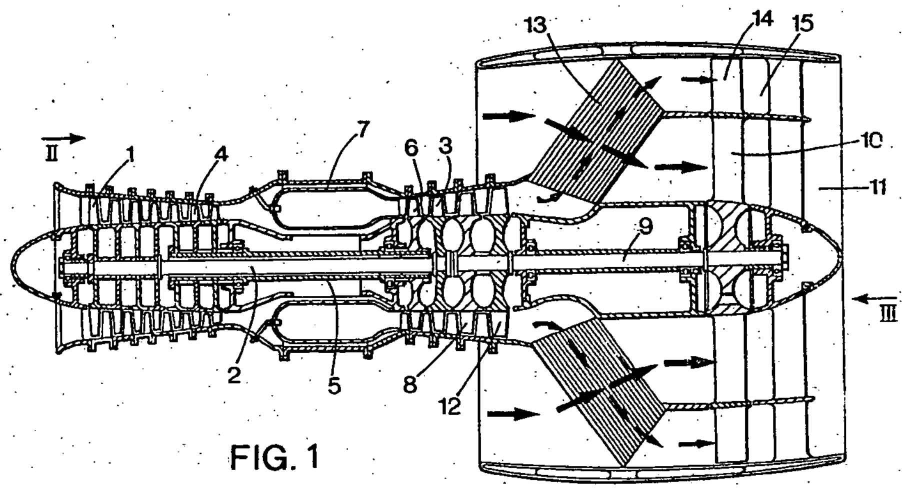

FIG. 1

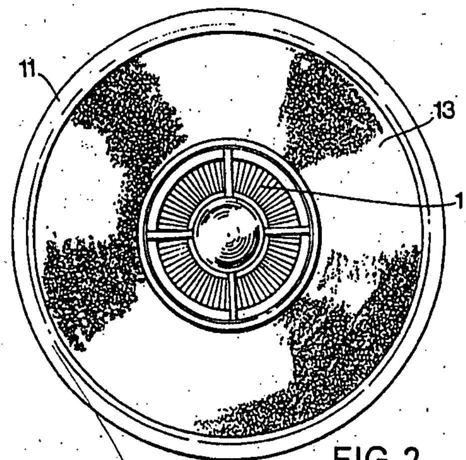

FIG. 2

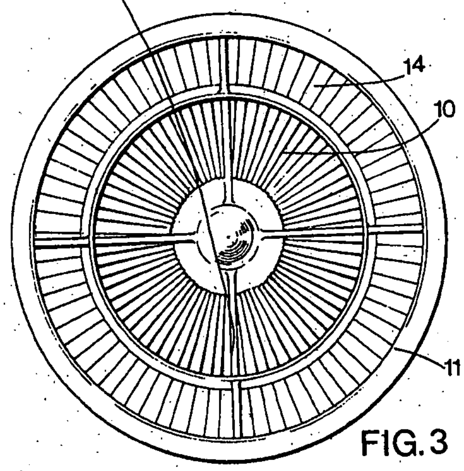

FIG. 3